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ECONOMIC INTELLIGENCE COMMITTEE

WORKING PAPER

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CAPABILITIES AND TRENDS OF SOVIET SCIENCE AND TECHNOLOGY

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WARNING

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FOREWORD

This contribution to NIE 11-6-56, "Capabilities and Trends of Soviet Science and Technology", was prepared at the request of the Scientific Estimates Committee and the Office of National Estimates for use by the SEC in the preparation of its draft of NIE 11-6-56. The contribution is responsive to specific questions or topics indicated in the Terms of Reference, dated 3 April 1956 and is not intended as an independent report.

This contribution was drafted in CIA/ORR, and informally coordinated by the EIC. The CIA/ORR draft was distributed to the EIC representatives of the IAC agencies, with a request for concurrence or suggested changes. The suggested changes were either taken into account in the present revision, or noted therein. The limited time available did not permit further coordination.

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B. Expenditures on Research and Development

Soviet research and development expenditures fall into two main groupings: 1) the financing of scientific research establishments and 2) outlays for "mastering the production of new products" and for technical improvements and inventions. The first group is thought to include the bulk of the country's research and development in the strict sense of the term, which includes basic and applied research and its application to new uses up to the point of design and production engineering. Scientific activity of this type is thought to be primarily the concern of the Academy of Sciences of the USSR and its affiliates, and of research establishments subordinate to the various ministries. Also involved in this activity are educational institutions performing research under contract and those staff members of educational institutions who have part-time employment with any of the various research establishments. The second group, which will hereafter be called product development, includes design and production engineering, experimental production, testing, prototype production and a variety of associated activities. This type of activity is primarily the concern of the production side of the various ministries.

The Soviets frequently disclose planned and/or actual annual expenditures for scientific research establishments. These include both budgetary allocations and funds from the various ministries. It is believed that these expenditures cover the first group defined above. In 1955, these expenditures were 11.6 billion rubles. The plan for the present year calls for a 17.2 percent increase in these outlays to 13.6 billion rubles. Over the last few years the series has shown a somewhat steeper upward trend than has GNP. Generally, however, this category of expenditures has been about one percent of GNP.

Properly, product development expenditures should be added in order to complete the picture. To date, it has not been possible to accurately quantify this category of expenditure but it can be defined and some gross idea of its magnitude can be suggested. One Soviet source states "....the principle itself of centralized reimbursement of the supplementary expenses of enterprises connected with the assimilation of new forms of production retains its meaning into the present time (1953)." Another amplifies this statement, indicating just what "expenditures for mastering production of new types of products" cover. These expenditures include the following:

1) design and construction of the article and working out of technological processes of its manufacture
2) design, construction, and working out of technological process of manufacture of special instruments and special appliances
3) working out and documentary preparation of norms for labor, expenditure of materials and complilation of normative calculations
4) testing of materials, semifabricates, instruments and appliances for the production of new types of articles
5) cost of articles used as models (minus proceeds from their sale after use)
6) testing of experimental articles, including expenses for correcting defects revealed in testing
7) modifying technical documentation upon transition into series or mass production
8) replanning, modification, and adjustment of equipment, in connection with organization of production of new types of articles
9) difference between actual and planned cost of production of first experimental model (or first lot) of this article.

The funds for these activities come from revenue obtained from one or both of two sources: 1) Budget allocations, and 2) Revenues obtained from the sale of output. It would appear that the bulk of these activities are centrally reimbursed since all improvements and inventions of interest to an entire branch of industry or of national importance as well as those for which the cost would have an unreasonable influence on the price of the product are supported by the budget. The allocations for these activities are a part of those for Financing the National Economy. The Soviets give no direct indication as to the size of these expenditures. Within the category, Financing the National Economy, the size of certain subcategories are announced and others can be estimated, leaving a residual which includes these product development costs as well as several other types of expenditures. While it is not yet possible to differentiate among the components of the residual, a suggestion of the magnitude of expenditures required for product development can be gained from US analogy. The 1957 US Budget indicates that the Department of Defense expenditures for product development (prototypes and equipment for test and evaluation, facilities for experimental production, standard supplies and equipment used in research development and test activities)

are at least equal to those explicitly labeled as research and development expenditures and that they are increasing substantially. Assuming that this relationship is fairly typical of development work in general in this country and in the USSR, then, as a minimum, Soviet expenditures for product development should amount to another 11-12 billion rubles in 1955. This figure fits reasonably within the budget residual noted above. On this basis, total Soviet expenditures for research and development, including product development, would account for about two percent of Soviet GNP.*

Total US research and development expenditures, including those of the Government, are estimated to have amounted to some 4 billion dollars in the fiscal year 1955 and are expected to be about 5 billion in fiscal 1957. Again using the relationship noted above, total US expenditures for research and development and product development should correspondingly amount to 8 billion and 10 billion dollars. Thus, currently, in the US research and development alone accounts for slightly more than one percent of GNP and about two percent when product development is included.

Over the recent past Soviet supporting expenditures per scientist have seemingly displayed stability, with a ratio of 5-6/1 existing between support costs and scientists' wages. Assuming this stability continues Soviet research and development expenditures can be projected for 1961 by applying the estimated growth of scientific manpower to current (1955-56) allocations for scientific research institutions. This procedure yields a crude value in the neighborhood of 20 billion rubles for 1961 and reflects a growth rate roughly comparable to that of GNP. Inclusion of product development, on the same basis as above, doubles this figure.

Recently, however, it has been rumored that the Soviets have drastically changed the salary structure for many professional and administrative workers. The affected group is allegedly large (possibly several hundred thousand) and is said to include scientists. A recent letter in the Soviet press is referenced which specifically attacks the wage disparity between research and teaching scientists as opposed to those involved in production. If a reduction of as much as 50 percent in scientists'

* Committee member from the Department of State notes in connection with the ORR estimate of Soviet expenditures on research and development that ".....the calculation based on US analogy introduces a very questionable assumption--viz. that the proportion of our expenditures for R/D and for production development are the same for the US Department of Defense as for the nation as a whole. This might be true by accident. To be persuasive, however, statistics on US expenditures for these types of scientific activity should be given for government agencies, private industry, and educational institutions. No doubt ORR realizes this and may claim that such statistics ar e very difficult to get; I can well believe the latter...... In any case, without having such a subsidiary estimate the analogy is very unconvincing and the results obtained for the USSR can be accepted only on faith."

wages were to take place across the board, it would mean a reduction of something like 10 percent in expenditures for scientific research establishments.

II C. Effects of Soviet Economic System*

It is not possible at this time to specify the distribution of Soviet scientific research and development effort as between basic and applied research. Similarly, the available information does not permit breaking down Soviet scientific research effort among military, basic industrial and consumer needs. It can be stated, however, that because of the little attention given to consumer industries in the Soviet economy, the overwhelming bulk of the effort is devoted to military and basic industrial needs.

The complete control of the Soviet state over all phases of economic and political life in the USSR gives it the power to direct the nation's activities as it sees fit. Through centralized planning long term objectives are established and effort directed towards their accomplishment. This general situation applies to and reacts on their scientific capabilities as well. Research and development, and the provision of suitable manpower are centrally directed and bolstered by economic and other incentives. The benefits of the perferred position of scientists relative to the majority in the Soviet Union are negated somewhat by the consequences of failure and by insistence on ideological conformity in certain fields -- primarily biology and associated fields of study. However, in spite of this and the difficulties and rigidities of Soviet comprehensive planning on a national level, the Soviets have achieved rapid progress in basic science and in the application of such knowledge to design and production.

II. F. Strengths and Weaknesses **

Soviet and US scientific efforts in research and development (in the narrower sense) are roughly proportional to the relative size of the respective economies. By contrast, scientific effort in production

* Committee member from the Department of State notes that " the first paragraph presents an undoubtedly true conclusion, but everybody knows this in a general way; what we need is more specific backup for the proposition that Soviet research and development efforts are next to nothing in the field of consumers' goods. In addition, some consideration should be given to the research efforts that are more or less directly related to public welfare -- e.g., in medicine, sanitary engineering, etc. The second paragraph doesn't seem relevant to the specific subject of this subsection and in our view tends to oversimplify the problem of estimating the impact of planning and ideological control on the Soviet scientific effort."

** Committee member from the Department of State notes: "......Insofar as this discussion of strength and weakness is based on an analysis of scientific manpower....... I think that ORR should present more specific quantitative data and a better analysis of the qualitative aspects of Soviet scientific manpower."

ORR comment: It is felt that more specific data regarding the quantitative and qualitative aspects of Soviet scientific manpower will be covered in contributions addressing themselves to II E. and the first sentence in II F. of the terms of reference, hence no attempt is made to discuss these aspects in greater detail.

activities, including product development, show a markedly higher provision of scientists, including engineers, as compared with the US. With a non-farm labor force roughly 75 percent of and a GNP of only about 40 percent of that of the US, the Soviets have some 50 to 75 percent more physical scientists and engineers engaged in production work, i.e., not engaged in research and teaching. It follows, then, that for this latter group, any or all of the following conditions apply: 1) they are qualitatively considerably inferior on the average to the equivalent US group, 2) they are being utilized in an inferior fashion, 3) they are doing very much more scientist intensive product development work, and/or 4) they are needed in profusion to provide a partial compensation for the lower productivity of the labor force.

To some extent their selection and incentive systems are responsible for diverting their best talent into the academic and research fields. Those students with the best academic records are funneled into research and teaching. Also the monetary rewards are far more favorable in these fields and higher esteem is accorded to those engaged in such work. At the same time, the Soviet desire to increase productivity is marked. The increases in the industrial labor force that led to large increases in output in the past are not in sight for the future except to the extent that the recently publicized military personnel cuts are carried out and some fraction of the personnel released are absorbed by industry. Even so, gains in output of the magnitude envisaged in their announced plans will still have to be accomplished largely by raising the productivity of the individual worker. This pressure for increased productivity seems to have been extended to scientific workers as well.

The recent budget speech stated that duplication of research effort which exists in a number of cases must be eliminated. The recent rumor indicates that implementation may take the form of wage cuts for the research scientist to redress the great disparity between the remuneration of the research scientist and the production scientist. One effect of this leveling should be to encourage better men to engage in production activities. Another effect is the probable improvement in the morale of those presently engaged in production.

II G. Dependence on Trade

In the development and manufacture of scientific equipment and instruments the USSR is approaching a state of self-sufficiency. In the years following World War II, the USSR was the principal customer of the established East German optical and scientific instruments industry. By 1954, however, Soviet

orders commenced to decline sharply in volume, and have since continued at a very modest level. Since large importation is not possible from other Bloc sources, and has not been observed in noteworthy quantities from non-Bloc countries, it appears probable that Soviet production of scientific equipment and instruments is reasonably adequate for domestic needs in most areas of scientific activity.

The Soviet Sixth Five-Year Plan calls for the establishment of 30 new instrument producing plants in the plan period. While the major emphasis in their output will undoubtedly be on production and control instruments suited to mechanization and automation of industry, the addition of these facilities for precision production will add to the capability of the USSR to supply its needs for scientific instruments and equipment.

IV. Soviet Capabilities in Research and Development Related to Military and Industrial Technology

A. Industrial Technology:

On the basis of a survey of key categories, Soviet industry, broadly speaking, appears capable of arriving at the same general frontiers as the advanced nations of the West. In their technical literature they give evidence of being familiar with modern industrial techniques and they are capable of adapting and introducing these techniques, whether self-developed or borrowed, into their rapidly expanding industrial base. However, it should be remembered that to a considerable extent Soviet progress has been made possible by a driving emphasis on exploiting and/or duplicating the machines and methods already in use by the West.

In addition, their industry is characterized by contrasts in technology since there is a much wider variation in the extent of application of new techniques among the individual plants of an industry than occurs in the more competetive industries of the non-Soviet sphere. Thus, on a comparative basis, Soviet industry, particularly in the heavy sector which has received greatest emphasis in their planning, can, in general, be considered as employing roughly equivalent "best" technology in its new plant but considerably lower "average" technology on an industry wide scale.* As a result, the industrial labor force of the USSR which is comparable in size to that of the US produces only about one third the output.

This latter point is more a matter of economic interest, bearing on investment and over-all production capability and does not relate as specifically

* Committee member from JIG notes in this connection that "USSR design technology is limited to 'best' practice consistent with its production capability and in many instances cannot be compared with products of the West. It will be noted however that such products will generally meet USSR requirements."

to the scientific and technological capabilities of the USSR. Nevertheless, the high growth rate of the Soviet economy and their possible recognition of the problems of obsolescence would tend to indicate that the gap between "best" and "average" performance may narrow considerably in the future. Currently, however, and for the immediate future the over-all level of technology in Soviet industry will remain below that of the US, but its major plants should compare quite favorably with those in the US. Some examples of the status of and/or recent developments in the technology of selected Soviet industries (electronics, natural resources, basic industries) and the improvement of productivity follow.

1. Electronics

On the basis of the variety and quantity of complex electronics gear observed during the past five years, the more recent technical exploitations of Soviet components and equipment, and occasional reports on specific industry operations, it is concluded that the USSR has built up a relatively high level of technological competence in electronics. It is apparent that wide variations in production methods and plant machinery continue to exist between individual plants. It is known, however, that several facilities are engaged in the manufacture of specialized production machinery for sectors of the electronics industry and that some of these machines incorporate highly effective designs, comparable in every respect to units available in the West.

The Soviet electronics industry is now able to mass-produce sub-miniature tubes and production of transistors may have passed the experimental stage. An analysis of sample tubes and data on Soviet tube plants indicates that the

new tubes are comparable in quality to corresponding American tubes and that they are now being produced in quantity. Sample transistors are not available, but Soviet technical literature suggests that production has passed the experimental stage. It should be noted, however, that the United States mass-produced sub-miniature tubes, especially for use in proximity fuses, during World War II, and that transistors, which were produced in the United States in 1952, were probably not produced in the Soviet Union before 1955.

2. Natural Resources

a. Petroleum

The volume and quality of literature published in the USSR on the application of geological and geophysical sciences to petroleum exploration attest to the comprehensive knowledge available to the Soviet petroleum industry. The chief geologists of the Ministry of Petroleum Industry of the USSR have indicated that geophysical prospecting is widely practiced by the Soviets. Gravitational, magnetic, and seismic method have been in use for several years, and in 1954 a radioactive method (probably the scintillometer) was introduced. It appears that the theoretical development of geophysical methods of petroleum exploration in the USSR is approximately on the same level with that of the Free World. The USSR appears to be several years behind the Free World, however, in the efficient use and in the relative extent of application of the more modern techniques.

The Soviets seem fully cognizant of the latest advances in the techniques of petroleum production throughout the world. Russian boasts of technological

success, however, are at times nothing more than references to production techniques which have been applied for years in the US. Two examples of the above are hydraulic fracturing of the geological strata to increase the flow of petroleum toward the well, and contour flooding as a secondary recovery system to increase production from fields where strata pressures are low.

The Soviets are currently propagandizing the use of three drilling techniques for which they claim world leadership. The first of these is turbine drilling which is used for 2 out of 3 wells in the USSR. The second is the use of ordinary water rather than a "mud" as a drilling fluid. The third is dual-well drilling or the simultaneous drilling of two wells with one drilling rig. While it is true that these three techniques are far more widely applied in the USSR than in other areas, peculiarities distinctive to USSR geology have caused their use to be emphasized. Turbine drilling is ideally suited for hard rock drilling, and water is the optimum power fluid as well as a suitable drilling fluid under these conditions. Its effectiveness can be judged by comparing USSR and US experience under similar geological conditions. The rate of penetration of the turbine drill under hard rock conditions is perhaps 2 to 3 times that of the rotary techniques used in the US. However, on the basis of over-all effectiveness in the utilization of their equipment the Soviets lag behind the US by some 50 percent in meters of well drilled annually per rig since their "on bottom" drilling time is roughly 10 percent of total rig time while US experience is about 40 percent. Under softer rock conditions the Soviets continue to employ the more conventional rotary drilling techniques.

Recent US interest in Russian advances in turbine drilling centers around turbine design and the possibility of combining the Russian turbine with US drill bits for special applications where hard rock is encountered.

In the field of refining, the level of Soviet technology can not be judged on the basis of a comparison with Free World technology. Free World refineries, in general, are designed to maximize the yield of aviation gasoline and motor gasoline from crude oil. This is not the case in the USSR where emphasis is placed on kerosene and diesel fuel yields. In limited areas where comparisons are possible, the Soviets appear to be well versed in the latest techniques and to be carrying out advanced research on problems peculiar to their operations. There is strong evidence however, to indicate that refining losses are considerably greater in the Soviet Union than in the US.

b. Coal

The Soviets claim that their coal industry is the most mechanized branch of the national economy. The development and use of combines, which cut and load coal simultaneously without blasting, has been a significant Soviet accomplishment and they have contributed greatly in raising coal output. While not a unique Soviet development, designers and engineers have designed and built satisfactory combines (cutter-loaders) for mining seams of medium thickness, as well as conventional cutting machines, mobile loaders, scrapers, belt conveyors and large mine locomotives. Recent efforts have been devoted to creating new combines for mining thick as well as thin seams, mechanical propping and improving other types of equipment. Special emphasis is being laid on the machinery necessary for complete mechanization of coal mining, which was to be introduced at 200 working faces in the major coal basins by the end of 1955.

In order to cope with the difficulties of mining thick and steeply pitching seams of coal, a new hydraulic method of underground mining was tried in 1952, apparently with success. A hydromonitor directs a jet of water under high pressure against the coal face. The coal is broken and carried away by the water through steel troughs to a crusher and is then pumped to the surface where it is dehydrated. It is claimed that one hydromonitor can remove up to 200 tons of coal per shift and cuts costs by more than 50 percent compared with other methods.

For strip mining the Soviets have been manufacturing and procuring from the Bloc a large volume of various types of equipment, including massive bridge-type dredgers, draglines, power excavators, bull dozers and trucks. In October 1955 it was announced that the most powerful walking excavator in the USSR had been tested at a strip mine in East Siberia. This excavator, weighing 1,500 tons, has a 65 meter jib and scoops 20 cubic meters of earth at a time or about half the capacity of the largest made in the USA.

3. Basic Industries

a. Steel

Generally, Russian steel making technology is on a par with leading Western nations, including the US. The results obtained by the application of technological advancements to the various metallurgical processes have had a significant impact on product quality and on productivity in the Soviet steel industry. While most new steel plant technology is well known to all advanced industrial nations, they seem willing to adopt new techniques on an ambitious scale.

The application of new technology to different segments of Soviet ferrous metallurgy has varied markedly. Russian effort has been directed primarily to blast and open hearth furnace processes and on high temperature alloy steels much of which is used for military applications, while in comparison rolling mill and finishing line technology have been permitted to lag. The emphasis has been on obtaining maximum production from their newer iron and steel making facilities. On the other hand, the failure to improve finishing equipment has resulted in less variety of finished products to serve specific applications than is the case in the US.

Best Soviet blast furnace technology compares favorably with that of the US. Probably the outstanding achievement has been the integration of new technology at Magnitogorsk. Here the interplay between cleaner coking coal, a self-fluxing sinter rate of 85 to 90 percent, top pressure operation, mechanization, and constant blast humidification has resulted in what is believed to be the most highly productive blast furnaces in the world.* In steelmaking, technology has advanced furthest in the application of oxygen in open hearth furnaces. Other applications of note are the extensive use of chrome-magnesite refractories, the large size of furnaces, use of the continuous casting process, vacuum melting, and plans to introduce the oxygen converter process.

The Magnitogorsk and Kuznetsk combines and several others are quite the equal of the best in the US in terms of output of iron and steel per unit

* Committee member from JIC questions the use of "believed" in the sentence and suggests using "claimed." ORR has reports from non-Bloc observers which support the belief.

of productive capacity. Investment for technological improvements at these plants has been unstinted in a conscious effort to outstrip the best plants in the world and to serve as models for other Soviet steel works. Output per worker at Magnitogorsk is, however, twice the industry average; in the US the differential between the "best" and the "average" is substantially narrower. Thus, a much higher level of "average" technology is indicated in the US for the industry as a whole.

b. Electric Power

In 1954, thermal power plants in the USSR used 15,000 BTU per kilowatt hour. Thermal electric power plants of the US electric utility industry were at this efficiency level in 1948-1949. Thus, the most comprehensive index of efficiency of thermal electric power plants, the fuel consumption index, indicates that in the USSR average practice lags behind that of the US by a period of 4-6 years. The Soviets claim that in 1954 about one-third of the capacity of thermal electric stations was operating on steam of high parameters, i.e., in the order of 90 atmospheres (1350 psi) and 500 degrees Centigrade (950 degrees F.). About two-thirds of the capacity of the US electric utility industry operates with steam of similar high pressures and temperatures. The highest steam pressure utilized in the USSR at present is 170 atmospheres while in the US pressures of nearly twice that magnitude are being utilized. One of the goals of the Sixth Five-Year Plan is to put into operation by 1960 a steam turbogenerator with a capacity of 300,000 kw operating under steam pressure of 300 atmospheres.

In regard to transmission of electric power, recent applications of Soviet technology surpass that of the US with respect to length of transmission, voltages utilized and power losses sustained. They are, however, lagging

behind the US in the development of transformers and control and relaying devices. In general, it would seem that Soviet technology in the transmission of power equals or may even surpass that of the US. In this respect, it should be noted that their technological developments are influenced by problems of economic geography that are not faced to the same degree by the industry in this country, hence it should not be inferred that these developments are beyond the capability of the US industry or that they would be economically feasible in this country.

Considering all factors, it would seem that the US leads the Soviet Union in electric power generation technology by some five years at the present time. This gap has been narrowed considerably during the past 10 years and may be reduced somewhat further during the Sixth Five-Year Plan.

4. Improvement of Productivity

a. Automation and Mechanization

In terms of systematic knowledge about automation the USSR has at least kept pace with the West. A survey of the Soviet industrial applications of automation and mechanization to date demonstrates that they have placed priority on selected industrial applications. The literature indicates that they are not satisfied with progress to date. It is apparent from their discussions that the majority of existing automatic lines were set up by tying together existing machines by transfer mechanisms of various types.

In the production of motor vehicles, including trucks, automation has proceeded extensively in both countries with the USSR trailing the US in the extent of application for the most part. In at least one aspect of motor

vehicle production, i.e., piston manufacturing, the Soviets have gone further in automatic handling than American manufacturers. By 1951, they had built and were operating an automatic plant for the production of pistons. This plant was described as automatic from ingot to packaged pistons. A second line, parallel to and with improvements on the first, was installed and operating by the following year. On examining the plans for these lines, American manufacturers at that time indicated that they could not economically go as far in eliminating transport labor because they could not enforce standardization and centralized control of model changes as could the USSR.

During the Fifth Five-Year Plan anti-friction bearing output in the USSR increased over 200 percent. A substantial portion of the increase resulted from the modernization of older types of machinery and the establishment of semi-automatic and automatic lines. Semi-automatic lines were created by installing new controllers on the machines themselves and adding conveyors and other automatic handling equipment. The first fully automatic lines for roller bearings with new specially-designed tools and complete transfer equipment between machines went into operation late in 1955. This automatic line is set up to take forged parts of a six-inch diameter conical roller bearing and perform automatically all the operations of machining, grinding, heat treating, testing, assembling, lubricating and packaging.

During the 1956-60 period, additional semi-automatic lines are to be established using existing machinery. Plans for construction of the fully automatic type line are not known. Over-all, the indications are that the USSR is counting on automation to increase the productivity of labor by reducing material-handling, as well as by the application of copy devices and other measures.

b. Machine building

Soviet ability to design and build metalworking machinery is believed to be equal to that of the US. Intelligence drawn from Soviet technical journals, exploitation of Soviet-manufactured machines, and observation of machines at trade fairs and Soviet plants shows they are building many models equivalent to our latest types of hydraulic and electronic-controlled machines. Photoelectric controlled machines have also been under development during the past five years. The electric spark and anode-mechanical methods of metal removal are being used more extensively than in the US.* Research and application of high speed cutting with ceramic tools also is further advanced in the USSR.*

During the past few years a large variety of advanced type machine tools were designed to be produced during the Sixth Five-Year Plan. These include machines incorporating the latest type of automatic tracer controls. Analysis of the specifications of these machines, as given in Soviet technical journals, indicates that they are comparable to advanced US designs now in production. Soviet production of precision machine tools such as jig borers, and optical profile grinders is still meager although increased production of such machines is within their capabilities.

Many modern techniques of metalworking and metal fabricating are used in the USSR. For example, gear rolling, i.e., forging of gears by rolling

* Committee member from JIC questions the accuracy of these statements suggesting a review of US accomplishments. ORR files indicate that these techniques were accepted and introduced into production lines earlier in the USSR and are extensively introduced into the Satellites also.

teeth on metal blanks or bars, is performed on a production basis in the USSR to a greater extent than in the US. Induction hardening, heat treating and flame heat treating as well as high speed trepanning and heliarc welding are further examples of modern metal fabricating techniques which are being used in the USSR although the extent of use of these techniques in the USSR as compared to their use in the US is unknown.

The over-all level of Soviet technology in the building of heavy metal-forming machinery is not clear. Whether such heavy special-purpose machinery as large skin mills, long spar mill, heavy forging presses or large extrusion presses comparable to those currently in use in US are actively in use in the Soviet aviation industry is unknown. That the Russians exploited both captured German equipment -- heavy forging and extrusion presses -- and retained German engineers experienced with such equipment is well known. Presumably the Soviets now have the capability to produce and utilize special-purpose machinery if they so desire. That they were able to reach high production on the MIG series of jet fighters without the application of such equipment is worthy of comment. Whether they now have available large forgings and thick milled skins for use on the more recent designs -- Badger, Bear, Bison, Camel, Farmer and Flashlight -- is open to speculation. In general, however, the USSR follows the European aircraft design practice which involves the use of general purpose tools in the manufacturing process. US practice has been geared to a concept of rapid build up after D-day with more emphasis on special purpose tools.

The technological level of the Soviet agricultural machinery industry has improved markedly in the 1950-1955 period in a number of the larger plants.

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Several dozen new, highly efficient automatic machine tool lines are scheduled for installation in the agricultural machinery industry for the production of spare parts and components. A few are already operating. By 1960, the over-all level of technology in this Soviet industry will remain below that of the US, but the major plants should compare quite favorably with those in the US.

e. Shipbuilding

The large expansion since World War II of the Soviet Navy and the recent additions to its merchant fleet was greatly facilitated by improved techniques in shipbuilding. Along with covered assembly facilities they have adopted the sectional assembly method of building submarines, tankers and other types of small vessels. Probably their greatest over-all advance has been in the field of standardization of design of vessels and equipment. This not only made feasible series production of many types of vessels but it permitted component standardization and therefore the mass production of components that could be used by many shipyards in many designs.

f. <u>Product Development Lead Time</u>

Comparatively, product development lead time, that is, the time elapsing between initiation of design and the beginning of series production, in the Soviet Union seems not to have been influenced so much by factors relating to personnel, facilities, equipment or techniques as it has by those relating to plan, decision and risk. This is particularly true in the development of

military weapon systems and components. Such developments are, of course, governed by the necessity of maintaining strategic comparability, if not superiority, and must be geared to the pace set by a potential adversary. In this respect, the Soviet Union over the past decade has been in the position of a nation trying to catch up which simplifies to some extent the planning aspects of their development problem. Two defense related industries, the most affected, in general, by technological advance, are the aircraft and electronics industries.

In aircraft, the Soviets have had marked success in compressing product development time. For example, it is generally thought that Soviet lead time on the Bison heavy jet bomber was about four years as compared with about eight years for the B-52. In developing and producing other aircraft, their lead time has also been considerably less than that of the US.

Their success in this respect has been largely due to an ability to follow through without delay on high priority projects and their willingness to take shortcuts and risks such as those attendant upon starting series production before all features of the prototype have been completely tested and evaluated. Also, the time to reach high volume output has been shortened by holding design changes to a minimum and by using as few different materials as possible, by limiting the design of parts and components to the minimum loads and functional requirements and by designing to maximize the use of semi-skilled labor and to eliminate bottlenecks in capital equipment and scarce skills.

The information available on the electronics industry is neither sufficient nor exact enough to allow specific comparisons between the USSR and the US. The time interval prior to production, even for similar projects, will vary widely in both countries, frequently depending upon a number of intangible

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considerations. Lacking the means for obtaining the necessary detailed information and the means for complete analysis, it is doubtful that any comparison based upon specific case histories would have much significance. There are, however, some known factors which would appear to have a bearing on this subject, and which are different between the US and the USSR.

Like industrial production, the Soviet electronics research and development effort is scheduled in accordance with an official plan. The existence of a plan will tend to reduce the frequency and magnitude of project changes and, as a result should reduce the delays normally caused by such changes. Also, there are indications that the Soviet electronics product design and development program tends to go further than is usual in the US towards the use of standardized subassembly units and components. Depending on the degree to which this can be done, a significant saving in time can be realized.

On the other hand, the rigidity inherent in an official R and D plan will in some cases prevent useful contributions from "unauthorized" groups. This system not only eliminates incentive for much self-initiated development work of a spontaneous nature, but frequently prevent the expenditure of effort on useful project, at least until some administrative planner has included the product in a plan.

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